New statistical approaches with consideration for extremes

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SafeWind

Wind Power Forecasting with Focus on Extremes

Workshop, Palais Brongniart, 31.08.12, Paris

New statistical approaches with consideration for extremes

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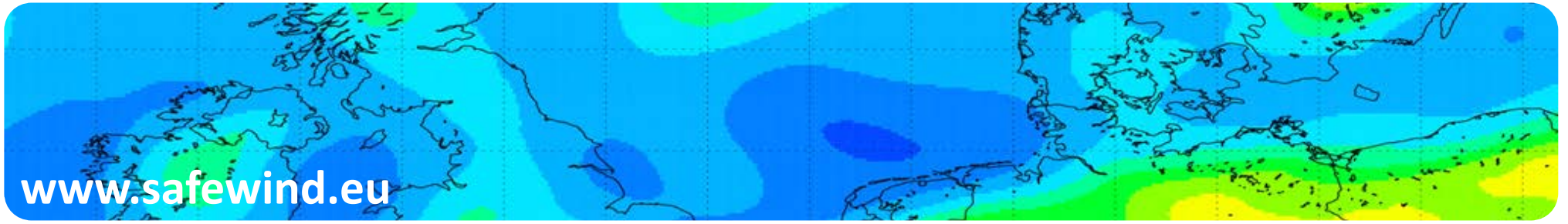
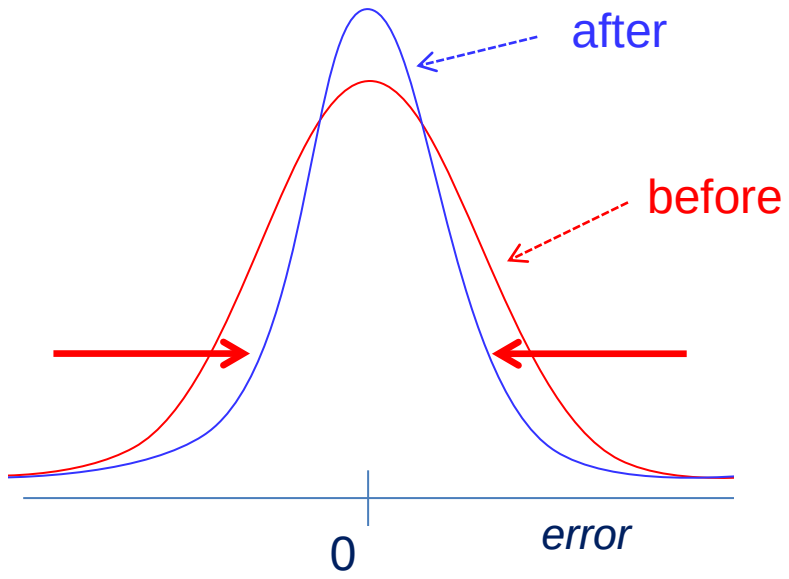


Outline

- Background, vision and objectives
- Some of the key advances:
  - Spatio-temporal analysis and correction of forecasts
  - Scenarios
  - Event-based view of the forecasting problem (ramps, cut-offs, etc.)
  - Regimes and forecast combination for error reduction
- Perspectives

Background – « before SafeWind »

- Distributions of forecast errors are often be seen as wide and heavy tailed…
  - Need to **reduce variance** (hence RMSE of point forecasts)
  - Need to "**cut the tails**" (extreme events)



- But also, forecasts do not inform about important operational aspects
  - **Reliable uncertainty** information
  - **Clear message** on specific type of events, as well as their timing
  - Further development of state-of-the-art ideas and proposal of new concepts!

Objectives – « after SafeWind »

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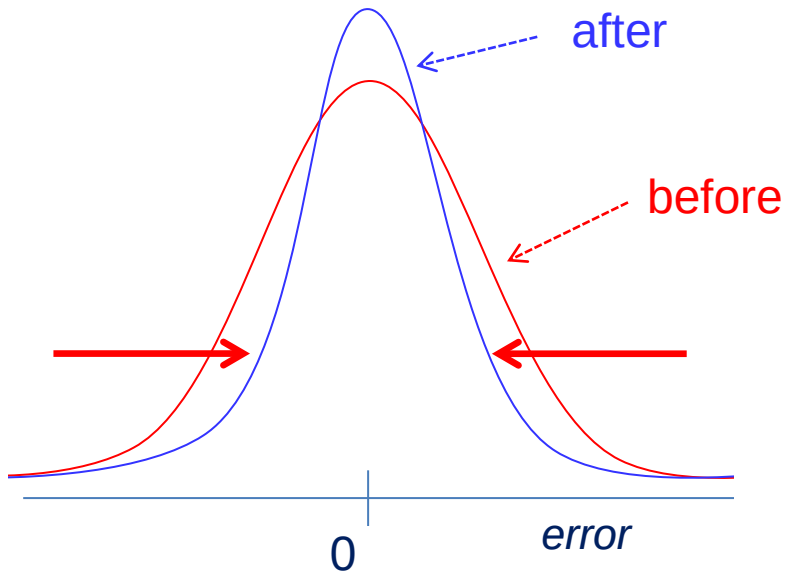

- But also, forecasts **do** ~~not~~ inform about important operational aspects
  - **Reliable uncertainty** information
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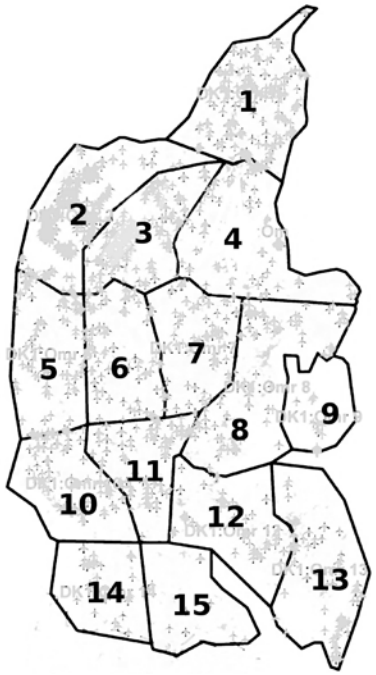
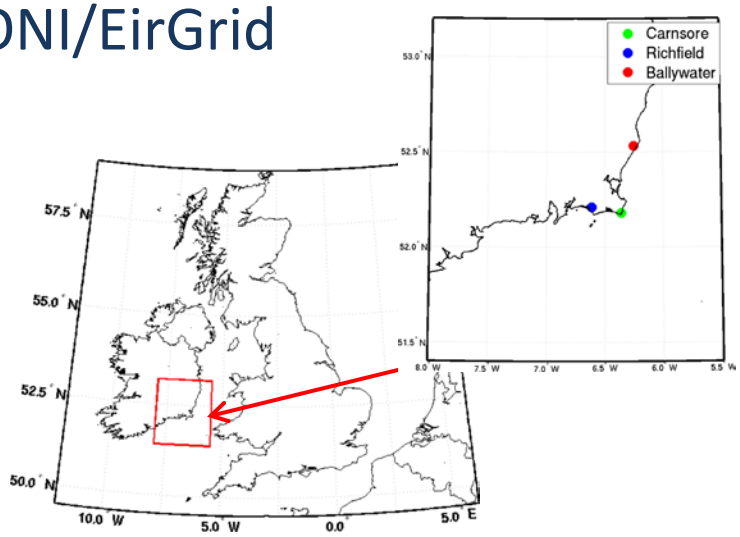
Playground

- Energinet.dk



- SONI/EirGrid

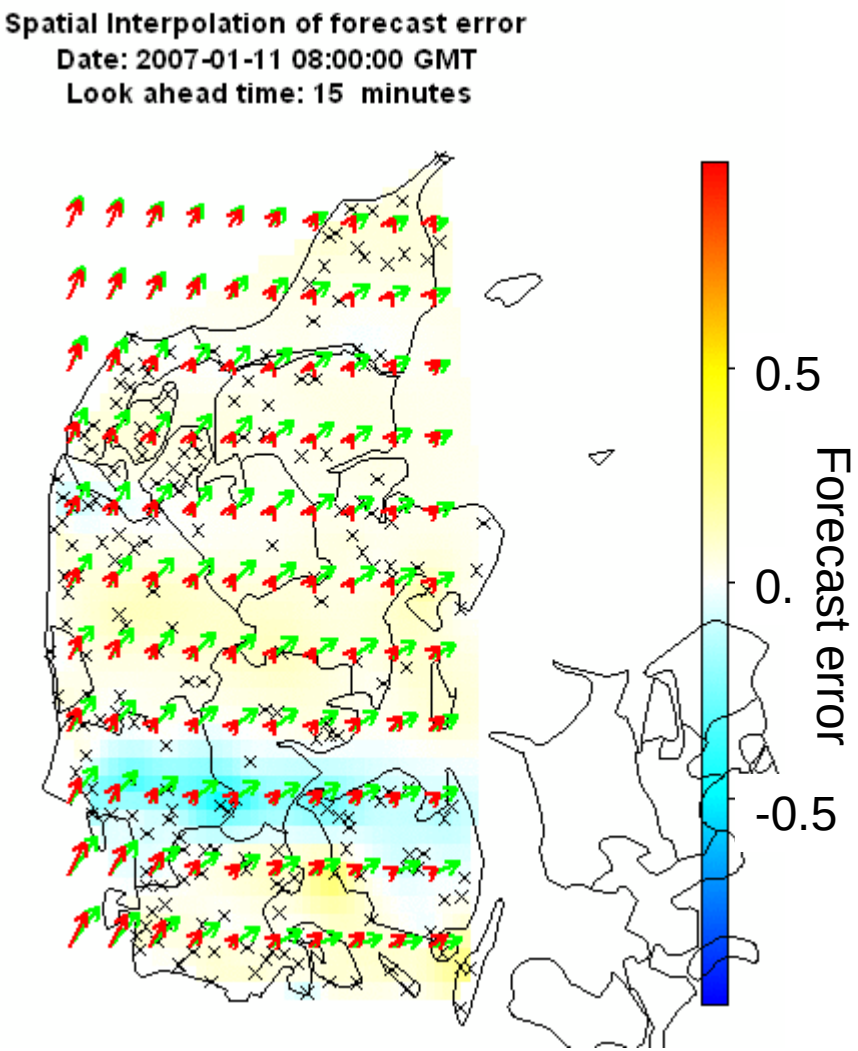


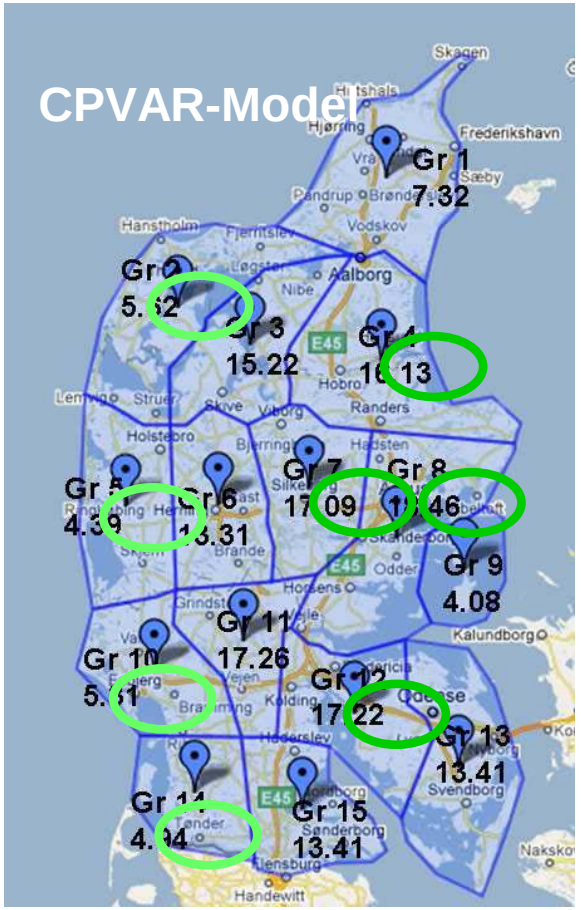
- France: EDF/RTE

- PPC

- India

Spatio-temporal aspects

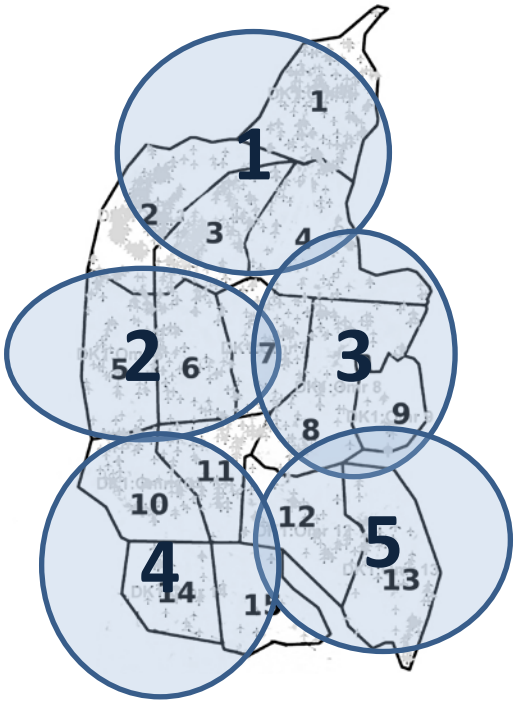


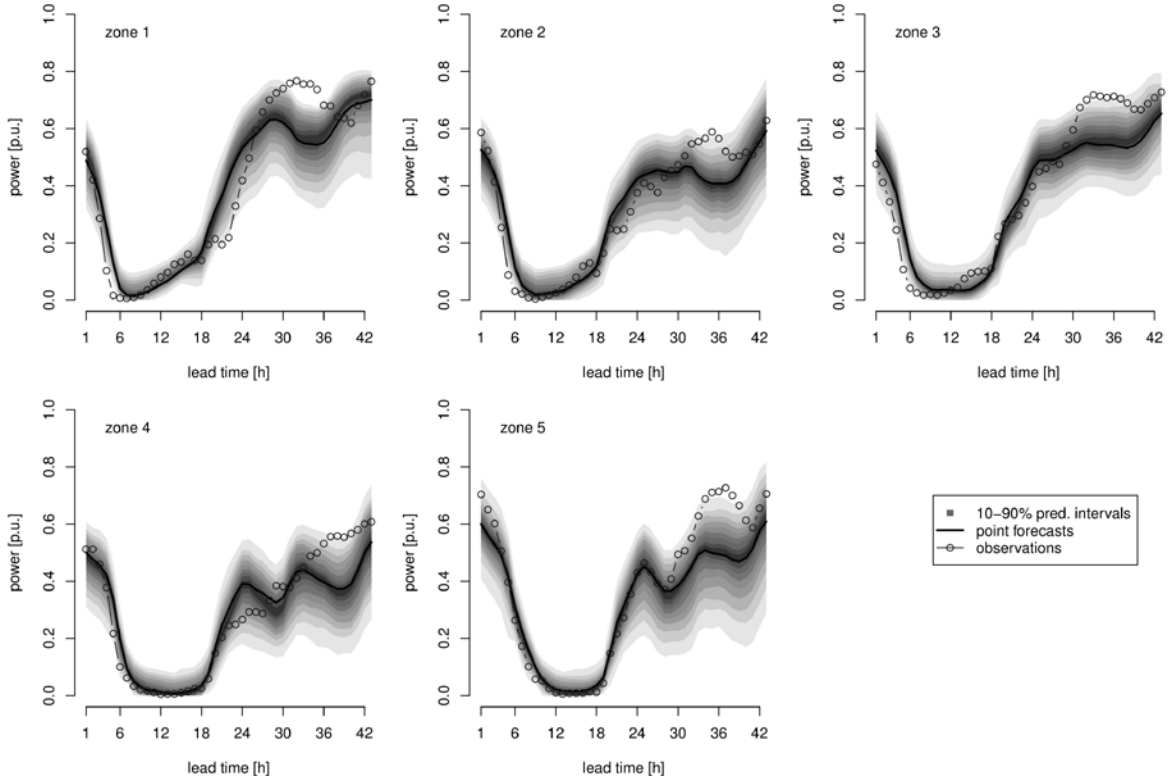


Reduction of forecast error (RMSE) up to 18% on the regional scale (1-5 hours ahead)

Probabilistic forecasting

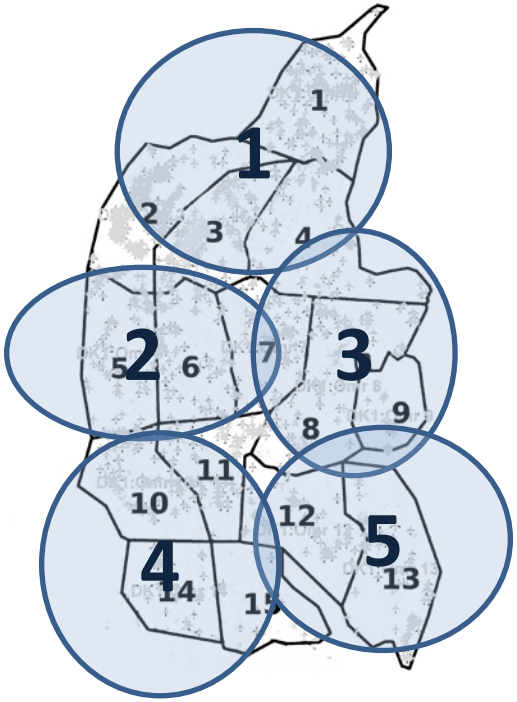
- **Large emphasis placed on developments of probabilistic forecasting methods**
  - Parametric and nonparametric
  - Statistical and artificial-intelligence based approaches (with point forecasts, meteorological information and new explanatory variables as input)

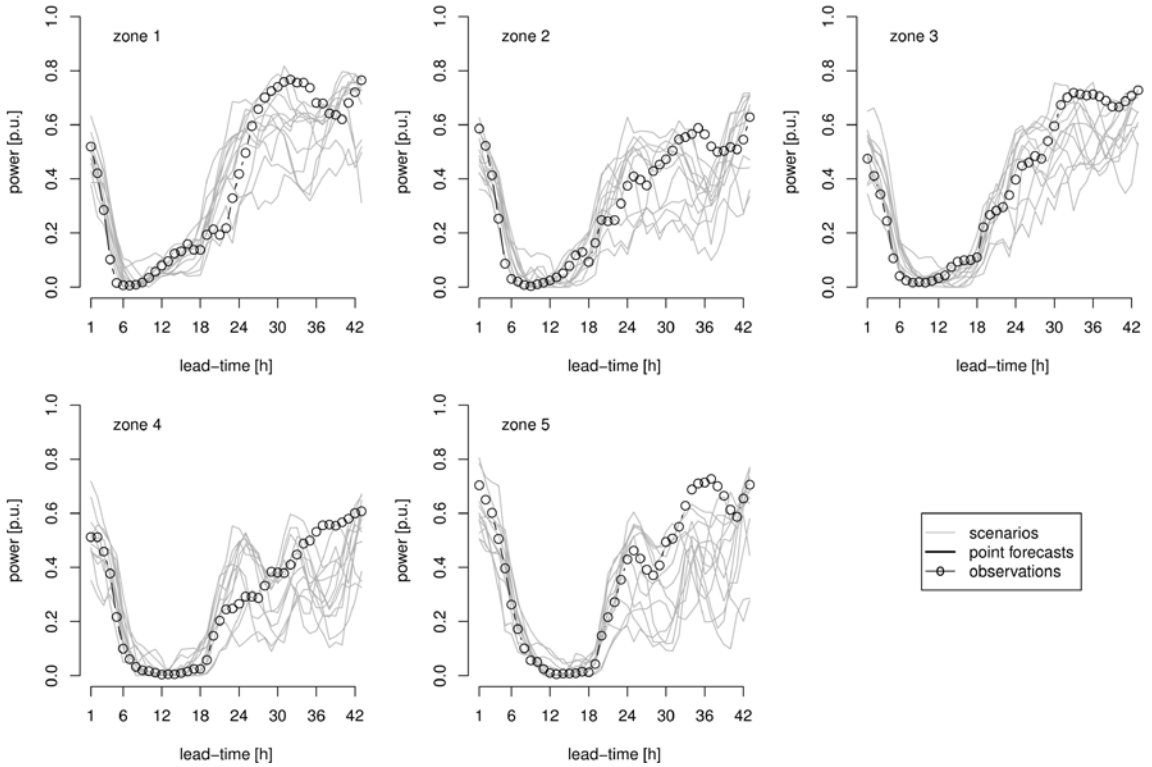




Scenarios of short-term power production

- The **most complete input to decision-making** algorithms, also informing of relevant space and time correlations, based on
  - Point forecasts and past measurements
  - Probabilistic forecasts
  - Ensemble predictions





Results overview

- Regarding **probabilistic forecasting**, proposal and evaluation of
  - New probability distributions
  - A set of rival (semi-)parametric approaches
  - New approaches to go from wind to power
  - New articifial-intelligence based techniques
  - Alternative explanatory variables for improving the skill of forecasts

- Resulting in
  - **Better description** of distribution tails (parametric approaches)
  - Overall **better calibration** of probabilistic forecasts
  - **Skill improvements** up to 15-20%

- For **scenarios**
  - **Overall methodology** for space-time scenarios
  - Proposal of standard **verification framework**
  - **Benchmarking/comparison** of statistical and ensemble-based approaches

Regime-switching modelling/forecasting

- Both meteorological and mechanical aspects make that the dynamics of power generation may suddenly change

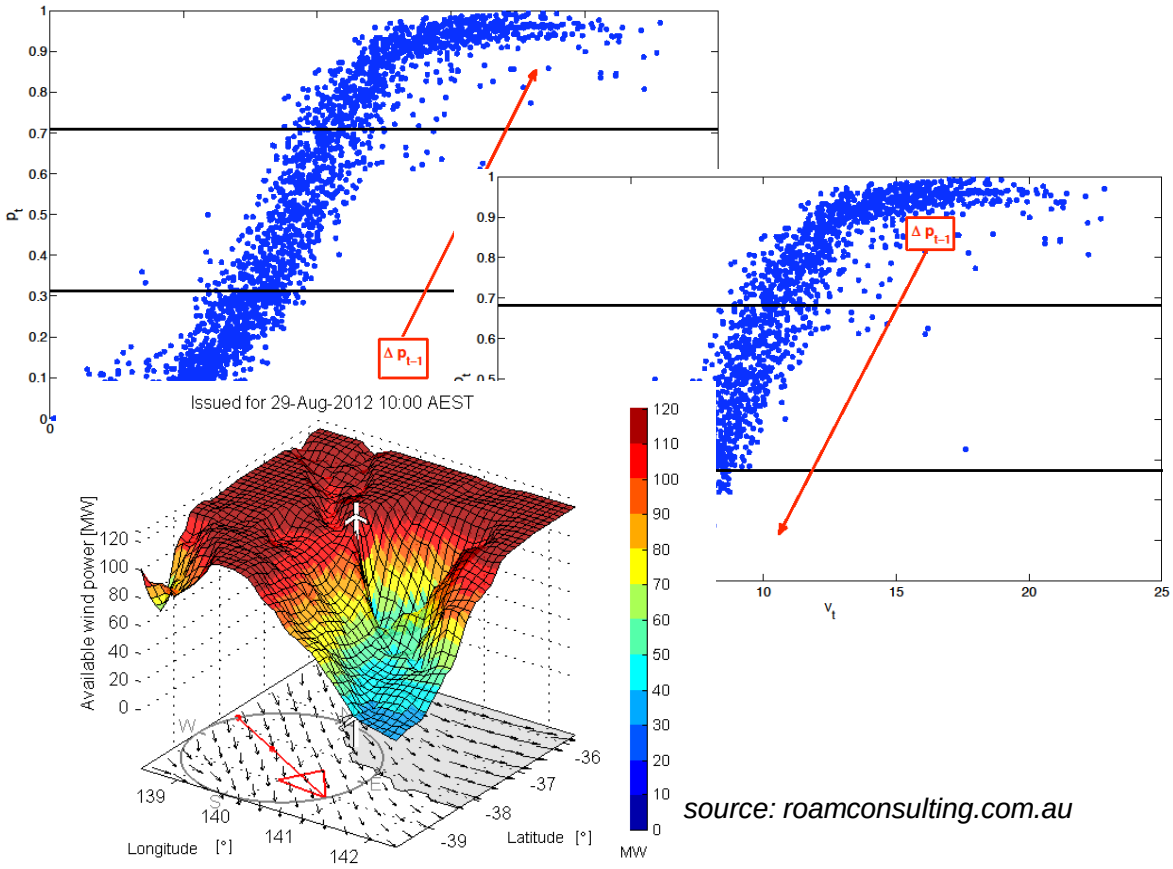
- Extensive analysis was performed to

0h

6h

48-72h

- Better undersand **time-series dynamics** themselves
- Finding **new variables** allowing to foresee change in dynamics, potentially offsite
- **Regime** information in meteorological fields

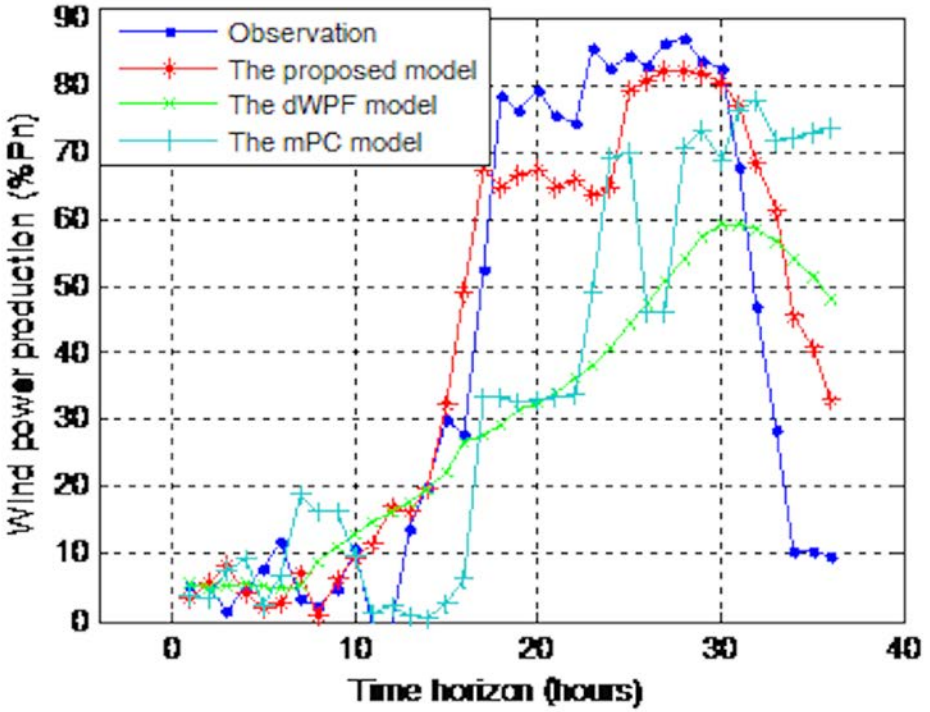


source: roamconsulting.com.au

Regime-switching – Illustration & main results

- *Example:*

  getting sharper forecasts of sudden changes in power production



- Main results:

0h

6h

48-72h

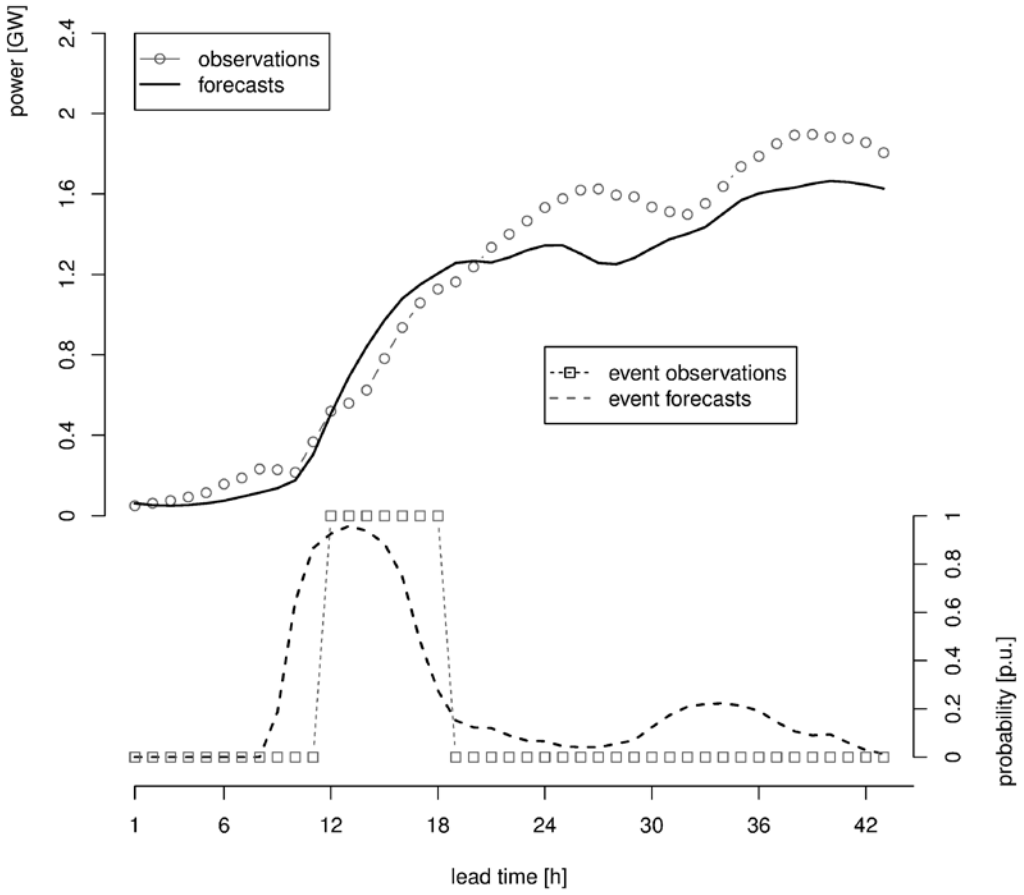
- Modeling of regimes in time-series dynamics provided insight and forecast **improvements of 5-10%** (RMSE)
- Including offsite information in regime modelling, though more complicated, also gave some additional percent improvements (very short lead times)
- Regime information from meteorological fields yielded **15% improvements** (RMSE)

Event-based prediction

- New paradigm in wind power forecasting, though quite common in climate and meteorological forecasting

- Events of interests are
  - Ramps
  - Cut-offs
  - High-variability

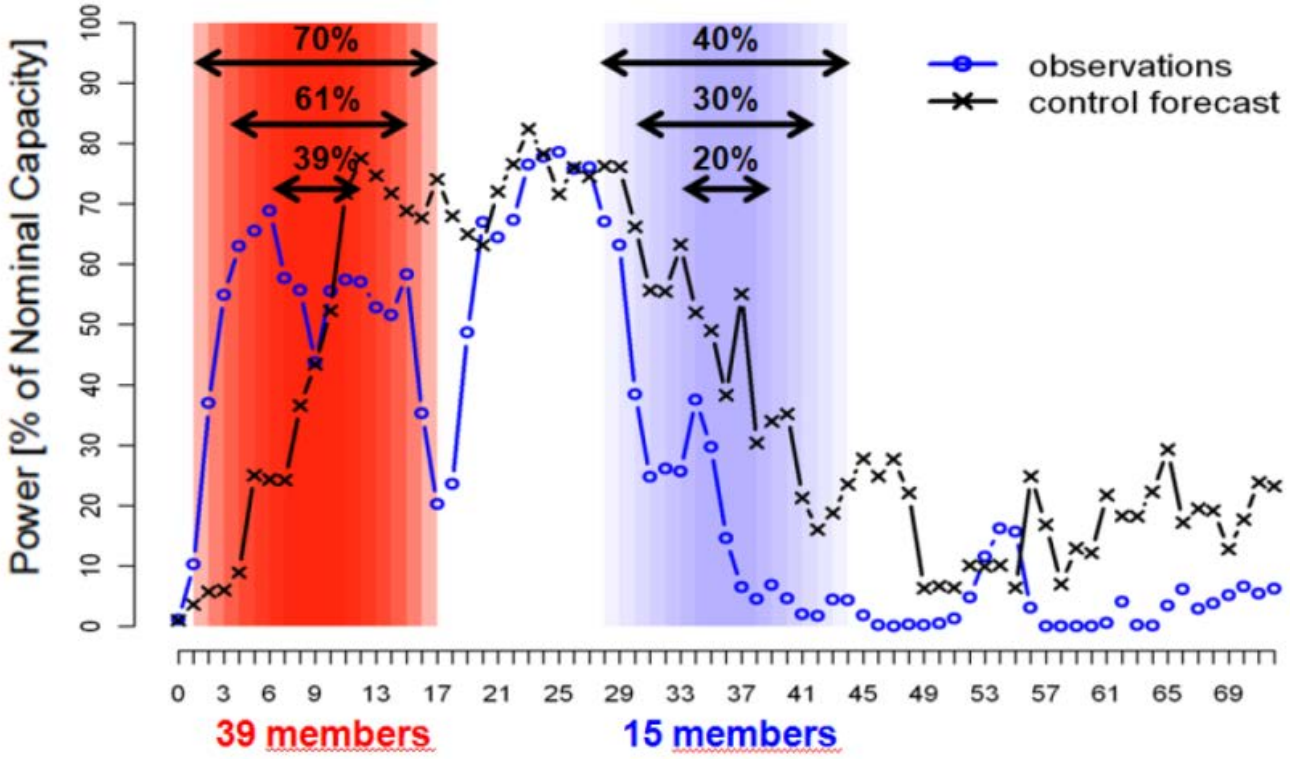
- Working with events has a lot of advantages!



Ramp forecasting

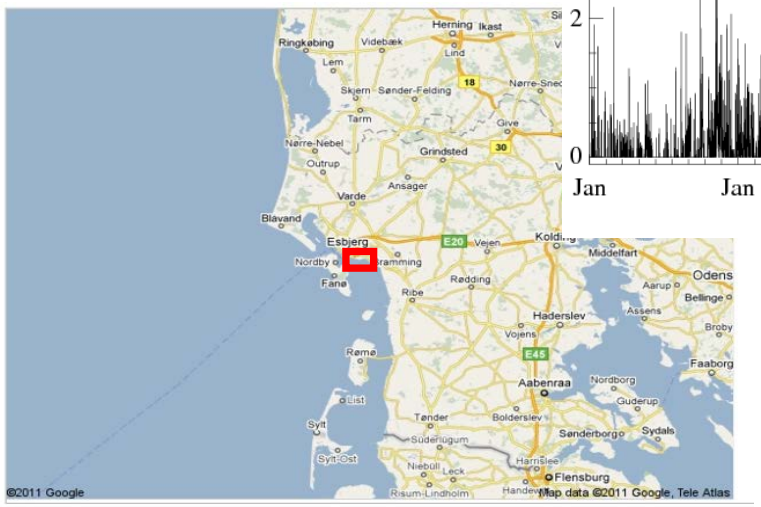
- New approaches developed for probabilistic prediction of ramp events:

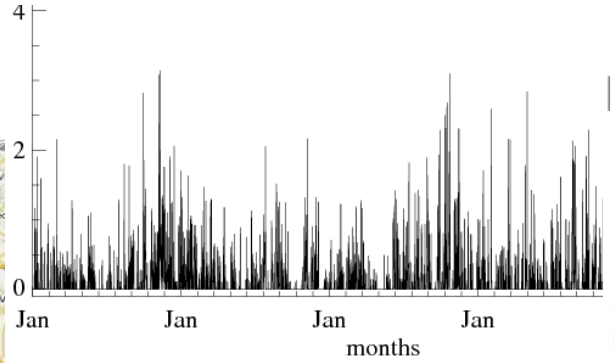
  - Based on Generalized linear models and deterministic / ensemble forecats
  - Informing of ramps occurrence AND timing
  - Implemented for demonstration

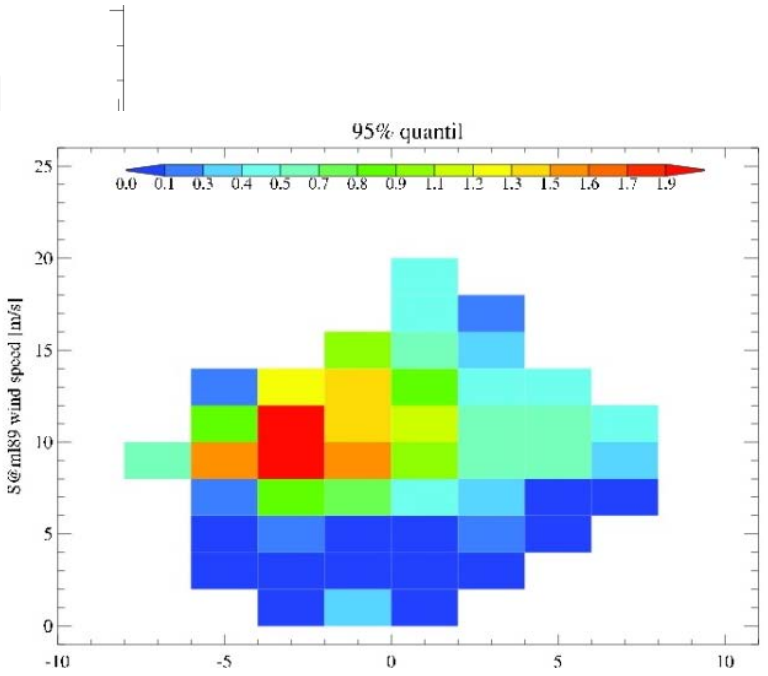


High-variability events

- High variability is problematic for power systems management, and difficult to predict…
  (Ex: www.youtube.com/fluctuations)
- Various metrics and approaches were used as a basis:
  - Volatility-based (collaboration with CSIRO)
  - Hilbert-huang transform and instantaneous frequency concepts
  - « totalfluc » metric representing sum of gradients



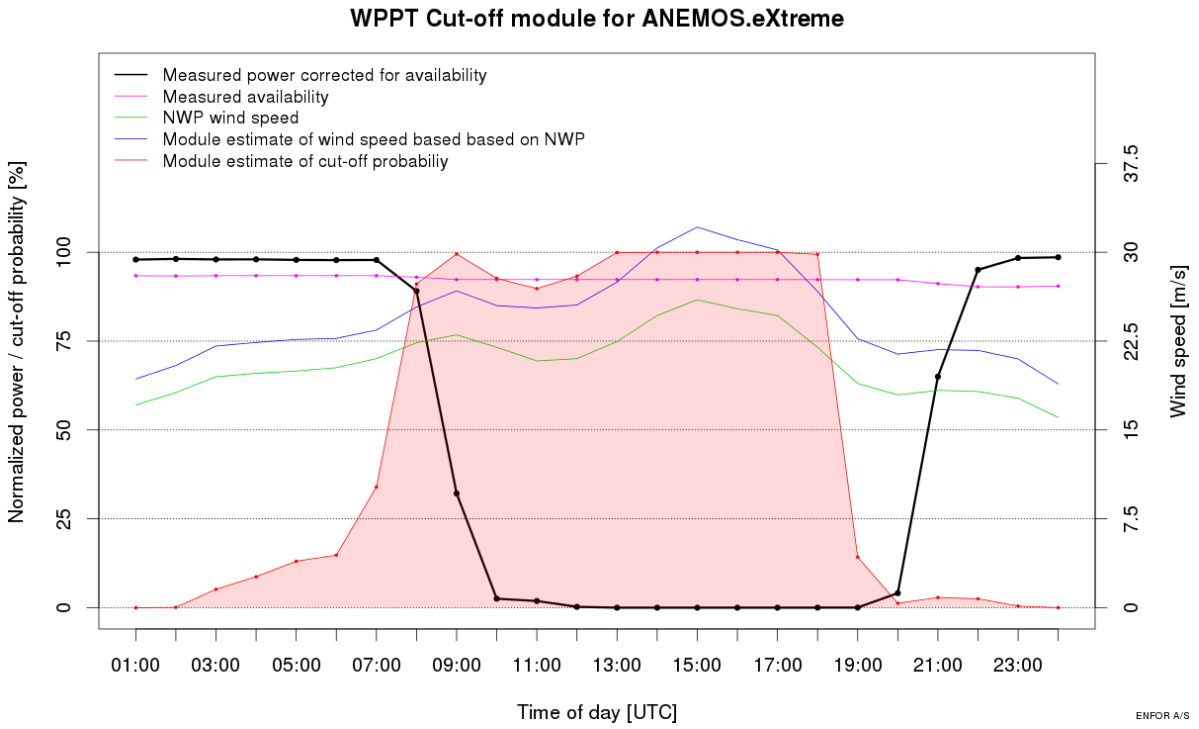




Cut-offs

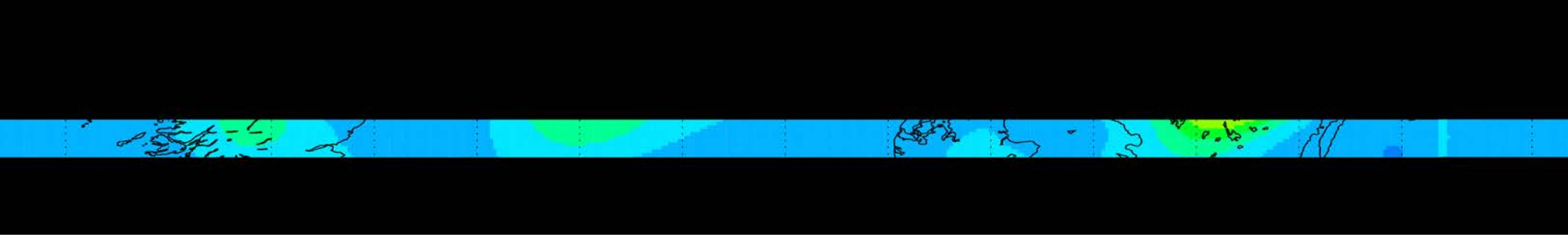
- Cut-offs are very important but rare events…
- Two parallel methodologies were developed for cut-off prediction based on local measurements and baseline wind forecasts
- Operational modules were delivered.

- Results:
  - Validation based mainly on wind information
  - Limited length of evaluation period
  - Cut-offs could be modelled directly in power curves used for forecasting



Perspectives

- The overall picture on what is going on in forecasting has totally changed:
  - New products eg. scenarios, ramp forecasts, etc.
  - Rival ideas for improving forecasts – and forecast quality is indeed improving!
- Overall some of these works and new paradigms are seen as leading internationally.
- In a more focused manner:
  - Regime switching is seen as promising for forecast improvements (<48 hours)
  - Probabilistic forecasting and scenarios are a must today
  - Some methodology (eg. for high variability) allow developing great insight, though not directly transferrable to forecasting products
- The input from meteorologists, wealth of test cases and interaction with forecast users can boost new ideas and developments.



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SEVENTH FRAMEWORK PROGRAMME

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